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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the application of:	)
	)
M. Anthony Stone, et al	) Examiner: GOODMAN, C.
	) Art Unit: 3204
For: HONEYCOMB REMOVAL	)
	)
Serial No.: 08/327,744	)
	) (Our File No. 3309P-65)
Filed: October 24, 1994	)

Springfield, MA, October 23, 1998

Box DAC
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Washington, D.C. 20231

Dear Sir:

APPELLANTS' APPEAL BRIEF

This appeal is taken from the final rejection dated June 10, 1996 in which, among other issues, claims 1-8 were rejected under 35 U.S.C. § 103 as being unpatentable over U.S. Pat. No. 5,167,721 to McComas and EP 207,059 to Peters.

This Brief accompanies a Petition To Revive this application. A Notice of Abandonment (Paper No. 14) issued on June 10, 1997, and a copy is attached as Exhibit A.

Real Party In Interest

The real party in interest in the above-referenced application is:

WATERJET SYSTEMS, INC.
Huntsville, Alabama 35807

Related Appeals and Interferences

There are no related appeals and interferences of which Appellants are aware regarding the above-referenced application.

Status of the Claims

Claims 1-8 are pending in this application. (A copy of the claims as finally rejected is attached as Exhibit B.) Claims 1-8 stand rejected by the Examiner under 35 U.S.C. § 103 and are presented to the Board in this Appeal.

Status of Amendments

An Amendment, Two Month Extension of Time and Notice of Appeal were filed on October 16, 1996 in response to the Final Office Action dated June 10, 1996. As a result of the Amendment, the objection in ¶¶ 4 and 5 of the Action to the specification and rejection of claims 1-8 under 35 U.S.C. § 112, first paragraph were withdrawn by the Examiner, as was an objection to the specification under 37 C.F.R. § 1.84.

An Advisory Action (Paper No. 13) issued on November 19, 1996 confirming that objection and rejection under 35 U.S.C. § 112, first paragraph were overcome, and the October 16, 1996 Amendment would be entered upon filing this appeal. The sole remaining objection is of claims 1-8 under 35 U.S.C. § 103.

Summary of the Invention

With reference to Fig. 1 and page 7, line 29 - page 8, line 2 of the specification, the present invention is directed to the removal of honeycomb 1 and associated braze from a substrate 3 using high pressure liquids. The honeycomb has a base and a ribbon direction 1a, and is typically fixed to the substrate by the braze.

The method comprises directing a pressurized liquid at an angle Ø of less than about 90° between the liquid and the substrate 3, e.g., the liquid travels in a direction that is *not* perpendicular to the surface of the substrate. The liquid is directed through at least one orifice of a nozzle 5 such that the liquid forms a liquid stream 7 upon exiting the nozzle. The liquid stream 7 is directed to strike the substrate 3 at the base of the honeycomb 1, and remove the honeycomb and associated braze from the substrate.

Various prior art methods exist for removing honeycomb from a substrate. Conventional methods are substantially limited to machining and grinding techniques, chemical immersion and debrazing using heat. These methods often have undesirable results such as irreparable damage to the substrate, thus rendering the substrate unsuitable for reuse.

In contrast, the novel method of the present invention utilizes a pressurized liquid stream directed to strike the substrate at the honeycomb base, where the honeycomb joins the substrate. In this manner, the liquid stream removes the honeycomb and braze from the substrate without damaging the substrate, such that the substrate can be reused.

Issues

The issue to be resolved is whether claims 1-8 are patentable over the combination of the McComas '721 and Peters '069 patents.

Grouping of the Claims

Claim 1 is independent; claims 2-8 depend directly upon claim 1. Claims 1-8 stand or fall together.

Argument

I. Claims 1-8 Are Patentable Over the Combined McComas and Peters Patents.

The combination of the McComas and Peters patents relied on by the Examiner in rejecting claims 1-8 under § 103 fail to teach or even suggest a method of removing honeycomb in which a liquid stream is directed to strike the substrate at the base of the honeycomb.

McComas merely teaches the erosion of plasma sprayed and sintered coating materials, in which a liquid jet impinges on the uppermost surface of the coating and erodes the coating until an underlying substrate or bond coating is exposed.

In McComas, a bond coat 2 is typically applied to the substrate prior to application of the coating material 1, and the coating material is then applied onto the bond coat. As illustrated in Fig. 1, discussed at col. 3, lines 23-42 and set forth in step (d) of claim 1, McComas uses a liquid stream 5 which is directed at and impinges on the coating material, and eventually erodes the coating material away until the underlying bond coat 2 or the substrate is exposed.

The liquid stream 5 is directed towards and impinges on the *topmost, exposed surface* of the coating. Accordingly, McComas teaches away from the invention as defined in claim 1, in which a liquid stream strikes *the substrate* at the base of the honeycomb.

Peters merely teaches severing sheet material, i.e., cutting completely through a multi-layer work piece 7 using cutting jets 31, 32 positioned on opposing sides of the workpiece, and is not at all concerned with the removal of the honeycomb from a substrate. (A copy of an English-language translation of Peters is attached as Exhibit C). The jets merely function as cutting blades for severing the work piece. The work piece 7 is a sheet of honeycomb material 73 which is *covered on both sides* by covering layers 71, 72. The jets impinge on both covering layers 71, 72 at angles a, b, and *cut completely through the covering layers and the honeycomb structure* 73, with the jets converging within the honeycomb structure.

Neither reference teaches or suggests the removal of honeycomb from a substrate, let alone directing a liquid jet to strike the *substrate at the base of the honeycomb* to remove the honeycomb from the substrate without damaging the substrate. Accordingly, Appellants request that the Board reverse the § 103 rejection issued by the Examiner.

A. <u>Claim 1 of the Present Invention</u>.

As discussed above, claim 1 is directed to a method of removing honeycomb and braze from a substrate using high pressure liquids. The honeycomb has a base and a ribbon direction.

The method comprises directing a pressurized liquid at an angle of less than about 90° between the liquid and the substrate. The liquid is directed through at least one orifice of a nozzle such that the liquid forms a liquid stream upon exiting the nozzle. The stream is directed to strike the substrate at the base of the

honeycomb, and thus removes the braze and honeycomb from the substrate such that the substrate may be reused.

As also discussed above, the claimed method removes the honeycomb and associated braze from the substrate, but without damaging the substrate. Moreover, the claimed method is flexible enough to process out of round parts without damage to the parts, and, where water or other non-toxic liquids are employed as the liquid, is environmentally sound.

B. <u>The Examiner's Rejection of Claims 1-8</u>.

In ¶¶ 6 and 7 of the Final Office Action, the Examiner asserts that McComas teaches stripping a layer of material from a substrate, and that Peters teaches cutting honeycomb material using a water jet. The Examiner then argues that it would have been obvious "to remove honeycomb and braze from a substrate using a water jet to facilitate ease of removal," and rejects claims 1-8.

As the Examiner concedes in ¶5 of the first Office Action (Paper No. 4) Peters does not teach or suggest "positioning the pressurized liquid [to strike the substrate] at the base of the honeycomb." The Examiner cannot now assert that *either* reference teaches or suggests directing a pressurized liquid through a nozzle, with the resultant liquid stream "striking the substrate at the base of the honeycomb" to remove the honeycomb from the substrate, as set forth in claim 1.

Appellants submit that the Examiner's rejection of claims 1-8 is not supported by the teachings of the McComas '721 and Peters '069 patents.

C. The McComas '721 and Peters '069 Patents Do Not Support the Examiner's Rejection of Claims 1-8 under § 103.

The Examiner asserts that the combination of the McComas and Peters references renders the present invention obvious. McComas teaches the removal *by erosion* of coating materials such as abradable, wear resistant and thermal barrier coating materials that have been applied either by sintering or plasma spraying.

Peters is directed to cutting completely through a flat material, such as a honeycomb sheet, using two liquid jets positioned on opposite sides of the sheet. Neither reference is directed to the removal of honeycomb and associated braze from a substrate, as set forth in present independent claim 1. Neither reference teaches or suggests directing a liquid stream to strike the substrate at the base of the honeycomb to remove the honeycomb from the substrate, as set forth in present independent claim 1. Accordingly, Applicants submit that the rejection cannot stand.

1. The Combination of the McComas '721 and Peters '069 Patents is Not Appropriate.

There is no teaching, suggestion or motivation for combining the McComas '721 and Peters '069 Patents.

McComas teaches the removal *by erosion* of coating materials. The liquid stream 5 is directed towards and impinges on the *topmost, exposed surface* of the coating until the coating and bond coat is eroded away, thus exposing the underlying substrate. McComas does not relate to the removal of honeycomb material from a substrate, and does not teach or suggest directing the jet at the base of the coating, let alone the base of a honeycomb structure.

Peters teaches severing sheet material that is covered on both sides by a covering layers using cutting jets 31, 32 positioned on opposing sides of the work-piece. Peters fails to teach or suggest a honeycomb material fixed to a "substrate", and accordingly there is no honeycomb "base" at which a cutting jet 31, 32 can be directed. Peters teaches that each jet 31 or 32 impinges on the side of covering layer 71, 72 opposite the honeycomb structure, and cuts entirely through the covering layer *and also the* associated honeycomb. There is simply no teaching, suggestion or motivation of removing the honeycomb structure 73 from either covering layer 71, 72, as is done using the present invention.

Peters' disclosure is limited to using liquid streams as cutting implements, e.g., shears for cutting entirely through sheet material. See, e.g., page 1 last line - page 2, line 2 of the attached translation, Exhibit B. As discussed above and as the Examiner concedes, Paper No. 4, Peters does not teach or suggest "positioning the pressurized liquid [to strike the substrate] at the base of the honeycomb." By teaching that the cutting jets 31, 32 strike the covering layers on the side of the covering layers *opposite the honeycomb*, and cut through the covering layers *and* the honeycomb material, Peters teaches away from the invention, in which a liquid stream strikes *the substrate at the base of the honeycomb* to remove the honeycomb from the substrate without damaging the substrate.

Moreover, Peters requires the use of opposing cutting jets on opposing sides of the material being cut in order to function in the intended manner. Peters does not teach or suggest that use of only a single jet is of any utility. As discussed at page 4, lines 19-24 of Peters, by using two generally opposing jets so that the jets converge within the material being cut, the energy of one jet generally cancels the energy of the other jet. Peters would not function in this intended manner in the event that a single jet were employed on only one side of the work piece 7. While Peters might function in some manner with only a single jet, the Peters jet still

would not be directed to strike a covering layer or "substrate" at the "base of the honeycomb" *to remove the honeycomb structure from the covering layer*, and thus cannot be used to render the present invention obvious.

In sum, McComas relates to the removal *by erosion* of coating materials applied either by sintering or plasma spraying, and uses a liquid jet which *impinges on the top surface of a coating* to erode the coating and underlying bond coat from the substrate. Peters is directed to cutting completely through a work piece, and uses a pair of opposing cutting jets which are positioned on opposite sides of a work piece and *strike the covering layers on the sides of the layers opposite the honeycomb structure.* Peters does not relate at all to the removal by erosion of coating materials. Neither McComas nor Peters teaches or suggests directing a liquid stream to strike a substrate at the "base of the honeycomb" to remove the honeycomb and associated braze from the substrate, and thus cannot be used to render the present invention obvious. Apart from the use of liquid jets, there is no teaching, suggestion or motivation for combining McComas and Peters. Where, as here, the prior art fails to teach or suggest the combination proposed by the Examiner, the combination of McComas and Peters is inappropriate and the rejection under § 103 (a) cannot be maintained. See, e.g., Ex Parte Levengood, 28 USPQ2d 1300, 1302 (T.T.A.B. 1993); and In re Fine, 5 U.S.P.Q. 2d 1596, 1598-99 (Fed. Cir. 1988).

2. **The Combination of the McComas '721 and Peters '069 Patents Fails to Support the Rejection Under § 103.**

Even if the combination of the McComas '721 and Peters '069 patents is appropriate, the combination fails to teach or suggest significant aspects of the claimed invention. The combination of McComas and Peters would still fail to teach or suggest directing a liquid stream to strike the substrate at the base of the honeycomb material to remove the honeycomb material and associated braze without damaging the substrate.

Turning to col. 3, lines 23-42 of McComas, a liquid stream 5 is directed towards and impinges on the *top* of the coating. Peters uses cutting jets 31,32 positioned on both sides of a work piece to cut entirely through the covering layers 71,72 and the honeycomb structure 73. The combination of McComas and Peters merely teaches the use of jets positioned on either side of a workpiece to erode a covering layer, or cut entirely through the work piece.

The combination of the McComas and Peters patents not only fails to teach or suggest the use of a liquid stream for removing honeycomb material and associated braze from a substrate, but also fails to teach or suggest that a liquid stream is directed to strike the substrate at the base of the honeycomb. Where the proposed combination fails to teach or suggest the claimed invention, the rejection under § 103 (a) cannot be maintained. See, e.g., In re Fine, 5 U.S.P.Q. 2d at 1600.

In view of the foregoing, Appellants request that the Board reverse the Examiner's rejection of claim 1. Since claims 2-8 depend from claim 1 and include all of the limitations of this claim, claims 2-8 are patentable over the McComas and reference for at least the same reasons discussed above in connection with claim 1. Accordingly, Appellants also request that the Board reverse the Examiner's rejection of dependent claims 2-8.

Previously submitted was an Appeal Brief, dated December 8, 1997, with check No. 22862 in the amount of $310 therefor. Applicants' are resubmitting, in triplicate, the Appeal Brief with exhibits, signed by an attorney of record and dated October 23, 1998. Applicants are submitting concurrently a Renewed Petition Under 37 CFR 1.137(b) in response to the Decision to Dismiss, dated September 23, 1988 (Paper No. 19).

Should an additional fee be necessary, please charge our Deposit Account No. 13-0235.

Favorable consideration is respectfully requested. The office is invited to contact Applicants' undersigned representative in the event that there are any questions.

Respectfully submitted,

By: Susan C. Oygard
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UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/327,744	10/24/94	STONE M	
08/327,744	10-24-94		

C2M1/0610

JS
DOMINIC J CHIANTERA
UNITED TECHNOLOGIES CORPORATION
PATENT DEPARTMENT
MS 524 00
HARTFORD CT 06101

EXAMINER	
GOODMAN, T	
ART UNIT	**PAPER NUMBER**
3204	14

DATE MAILED: 06/10/97

NOTICE OF ABANDONMENT

This application is abandoned in view of:

1. ☐ Applicant's failure to respond to the Office letter, mailed ____________.
2. ☐ Applicant's letter of express abandonment which is in compliance with 37 C.F.R. 1.138.
3. ☐ Applicant's failure to timely file the response received ____________ within the period set in the Office letter.
4. ☐ Applicant's failure to pay the required issue fee within the statutory period of 3 months from the mailing date of ____________ of the Notice of Allowance.

   ☐ The issue fee was received on ____________.

   ☐ The issue fee has not been received in Allowed Files Branch as of ____________.

   In accordance with 35 U.S.C. 151, and under the provisions of 37 C.F.R. 1.316(b), applicant(s) may petition the Commissioner to accept the delayed payment of the issue fee if the delay in payment was unavoidable. The petition must be accompanied by the issue fee, unless it has been previously submitted, in the amount specified by 37 C.F.R. 1.17(l), and a verified showing as to the causes of the delay.

   If applicant(s) never received the Notice of Allowance, a petition for a new Notice of Allowance and withdrawal of the holding of abandonment may be appropriate in view of Delgar Inc. v. Schuyler, 172 U.S.P.Q. 513.

5. ☐ Applicant's failure to timely correct the drawings and/or submit new or substitute formal drawings by ____________ as required in the last Office action.

   ☐ The corrected and/or substitute drawings were received on ____________.

6. ☒ The reason(s) below.

SEE NOTIFICATION OF DEFECTIVE NOTICE OF APPEAL OR DEFECTIVE BRIEF.

Eugenia Jones

EUGENIA JONES
PRIMARY EXAMINER
GROUP 3200

EXHIBIT
A

PTO-1432 (Rev. 4/93)

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
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Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.

EXAMINER

ART UNIT	PAPER NUMBER
	14

DATE MAILED:

NOTIFICATION OF DEFECTIVE NOTICE OF APPEAL OR DEFECTIVE BRIEF

1. ☐ The Notice of Appeal filed ________ is:

   A. ☐ Not acceptable for reason(s) that:

   (1) ☐ The Appeal fee required by 35 U.S.C. 41 (a)(6) and 37 CFR 1.17(e) was not submitted with the Notice of Appeal.

   (2) ☐ The submitted fee of $ ________ is insufficient. The appeal fee required by 37 CFR 1.17(e) is $ ________.

   (3) ☐ The Notice of Appeal was not timely filed.

   (4) ☐ The Appeal fee received on ________ was not timely filed.

   (5) ☐ The Appeal is not in compliance with 37 CFR 1.191 in that the claims have not been finally or twice rejected.

   (6) ☐ A Notice of Allowability was mailed by the Office on ________.

   B. ☐ Defective and should be corrected as indicated. Applicant is given a TIME LIMIT of ONE MONTH from the date of this letter OR the TIME REMAINING IN THE RESPONSE PERIOD OF THE LAST OFFICE ACTION, whichever is longer, to complete the appeal. NO EXTENSION OF THIS ONE MONTH PERIOD MAY BE GRANTED UNDER 37 CFR 1.136(a) or (b) BUT THE PERIOD FOR RESPONSE SET IN THE LAST ACTION MAY POSSIBLY BE EXTENDED. If the appeal is not timely completed, the application will be abandoned.

   (1) ☐ The Notice of Appeal is not signed.

   (2) ☐ Identification of the appealed claim or claims is required under 37 CFR 1.191 (b).

2. ☐ The Brief filed ________ is NOT acceptable for the reason(s) indicated below.

   The Appeal in this application will be dismissed unless the applicant makes the Brief acceptable. Extensions of time may be obtained under 37 CFR 1.136(a).

   A. ☐ The Brief and/or Brief fee is untimely. See 37 CFR 1.192.

   B. ☐ The requisite fee which must accompany the Brief has been omitted. See 37 CFR 1.17(f).

   C. ☐ The submitted Brief fee of ________ is not the proper amount. The Brief fee required by 37 CFR 1.17(f) is ________.

3. ☒ The Appeal in this application is DISMISSED because

   A. ☐ The fee for filing the Brief as required under 37 CFR 1.17(f) was not submitted or timely submitted and the period for obtaining an extension of time to file the brief under 37 CFR 1.136 has expired.

   B. ☒ The Brief was not filed, or was not timely filed and the period for obtaining an extension of time to file the brief under 37 CFR 1.136 has expired.

4. ☒ As the result of the dismissal in "3" above, this application:

   A. ☒ is abandoned since there are no allowed claims.

   B. ☐ is being returned to the examiner for disposition since it contains allowed claims. Prosecution on the merits is CLOSED.

EXHIBIT

CLAIMS

1. A method for removing honeycomb and braze from a substrate, said honeycomb having a base and a ribbon direction, comprising: directing a pressurized liquid at an angle of less than about 90° between the liquid and the substrate, through at least one orifice of a nozzle such that the liquid forms a liquid stream upon exiting the nozzle, the liquid stream striking the substrate at the base of the honeycomb, thereby removing the honeycomb and braze from the substrate,

77 whereby the liquid stream may be (revised.) reused

2. A method as in Claim 1 further comprising the step of forming a laminar liquid flow out of the nozzle, wherein said nozzle has an orifice and a bore which connects said orifice to a liquid supply, with said bore having sufficient length such that a flow of liquid from said liquid supply attains a laminar flow prior to exiting said orifice.

3. A method as in Claim 1 wherein the pressure of the liquid stream is above about 20,000 psi (about 1379 bar).

4. A method of Claim 1 wherein the pressure of the liquid stream is above about 30,000 psi (about 2068 bar).

5. A method of Claim 1 wherein the pressure of the liquid stream is (above) about 35,000 psi (about 2413 bar) to about 60,000 psi (about 4137 bar).

6. A method as in Claim 1 wherein said angle is about 35° to about 65°.

EXHIBIT

B

7. A method as in Claim 1 wherein said angle is about 40° to about 60°.

8. A method as in Claim 1 wherein said liquid stream strikes the base of the honeycomb in the ribbon direction.

TRANSLATED FROM GERMAN

EUROPEAN PATENT APPLICATION 0,207,069

Date of application: June 19, 1986
Date of publication: December 30, 1986
Applicant: VEW - United Special Steel Works, Inc., Vienna
Inventors: Dr. Eng. Henning Peters, Franz Trieb.

Method for separating or cutting a flat material, and a device for carrying out the method

The invention concerns a method and a device for cutting a flat material with cutting jets (31, 32) discharged by nozzles (21, 22) located on both sides, by means of a medium, preferably water, where the jets on the one hand, and the flat material on the other, move with respect to each other, for cutting workpieces (7) with covering layers (71, 72) held by self-supporting, essentially rigid materials, preferably an internal honeycomb structure (73), where on the one hand the workpiece (7), and on the other at least one set of two nozzles (21, 22) are located on both sides of the material at a distance (b, c) from its main surface (71, 72), and discharge jets of a fluid medium (31, 32) at a high pressure of at least 700 bar, which cooperate and meet each other preferably at an angle (γ) and can be moved and placed in relation to each other, where each of the meeting high-pressure fluid medium jets (31, 32) are kept at an angle that essentially differs from 90° (α, ß) along the entire cutting course, which is directed against the principal surfaces (711, 721) of the workpiece (7).

Method for separating or cutting a flat material, and a device for carrying out the method

The invention concerns a method and a device for separating or cutting flat materials, where "flat" means a material extending in two directions in space. Instead of a solid metal blade as the

EXHIBIT
C

cutting device, this method uses the directed jet of a fluid medium, particularly water.

US-PS 3,996,825 describes a method and a device for cutting a fiber mat, where nozzles located on both sides thereof direct a water jet at an angle with respect to each other, for cutting the fiber mat. The fiber mat, which e.g. is obtained in an intermediate step during paper manufacturing, lies flat on a supporting base and the two nozzles that discharge the water jets are supplied with water through a forked supply line and move in relation to the webbed fiber, while the water jets perform the cutting operation. The typical pressure of the two jets is indicated to be about 1.75 bar, the typical jet diameter is about 4.5 mm. It can clearly be seen in the drawing that the cutting heads comprising the nozzles, of which the lower one must be directed at a right angle against the material, contain typical low-pressure fittings. The nozzles are adjusted in an unchangeable manner, so that the jets that are discharged from them meet each other above the support surface inside the fiber mat, while the jet arriving at an angle from one side is deflected by the vertical jet on the other side, so that the resulting jet no longer impacts on the support. This known method can only be used to separate mats of loosely held fibers, which cannot be compared to precise cutting.

Furthermore, US-OS 51-142,186 describes a jet cutting method for materials which cannot be penetrated by the cutting jet, due to their toughness or thickness. With this method, two nozzles located on both sides of the material to be cut discharge cutting jets at two equal or changeable angles against the material, which results in a significant increase in the cutting depth. No indications are provided with regard to the protection of the inside of the material against damage from the high-energy high-pressure jets.

The present invention has the task of creating a cutting method for workpieces made of a self-supporting material extending principally in two directions, where the material does not offer any high resistance to the cutting jet - thus e.g. can always be cut with a single high-pressure jet - containing mechanically sensitive composite materials on the inside, such as a honeycomb structure, which makes a clean cut with narrow parting lines on both surfaces of the material possible, while the sensitive internal structure of the workpiece however is subjected to few disturbances.

The subject of the invention is a method for separating or cutting flat materials by means of jets of a pressurized fluid medium, preferably water, discharged by nozzles on both sides of the material, which intersect each other inside the material, where the jets on the one hand and the flat material on the other, can move in relation to each other in accordance with a desired cutting course, which essentially comprises the separating or cutting of flat extensions, particularly workpieces with two main surfaces made of self-supporting, rigid materials, especially composite materials, preferably with an internal honeycomb structure, where the workpiece on the one hand, and on the other at least the one set of two nozzles located on both sides of the workpiece, containing high pressure of at least 700 bar, preferably at least 1000 bar, meet each other preferably in the central area of the workpiece, preferably at a changeable and fixable angle with respect to each other, with a nearly uniform cross section and/or shape, where the fluid medium jets cooperate and move in relation to each other, where each of the high-pressure fluid medium jets, which impact each other, is directed against the principal surface of the workpiece at an angle that differs from 90°. It was surprising to find that the cited materials can be precisely cut in this new manner on both sides with two cooperating, finely focused jets of a high-pressure medium, without any expected destruction of the material due to the meeting

of the two cutting jets inside the material, which can result in jet clusters.

At the same time, significantly higher cutting speeds and fewer disturbances can be achieved with a clean cut. The method was found to be particularly suitable for edging and cutting composite honeycomb materials used for example in air and space flight, wherein covering layers of the same or different materials, such as e.g. glass, (illegible word), aramid or similar fiber-reinforced plastic and/or metal, particularly aluminum, with an essentially crosswise internal honeycomb structure, are joined to each other. Such materials cannot be cut with blades or punches in the usual manner without creating any disturbing deformation. It was shown with the usual fluid jet cutting with only one cutting jet, that the side of the material on which the jet enters exhibits a clean cut, however the cutting seam on the surface from which the jet exits is particularly irregular. Tests with cutting jets in a position according to the above cited US-PS, exhibit undesirable disturbances of the cutting aspect on the exit side, particularly when the jet is directed vertically against the material. A special advantage of the method of the invention is that a mutual destruction of the high energy of the two fluid medium jets takes place, so that the known problems with a jet catching device, which does not stand up for long against the high energy densities, do not take place. In addition, the angled direction of the cutting jets in relation to the main surfaces of the material must be such that, if these e.g. have an irregular shape, the cited and preferred angles in relation to the plane of the relative movement vectors of the workpiece and the jet must be kept in tandem.

It was shown that a high degree of cutting cleanliness can be achieved, and that the disturbances of the workpiece in the area impacted by the pair of jets are particularly small, if the cross

section surfaces of the two high-pressure fluid medium jets are adjusted to cover at least 90%, especially at least 95%.

In particular for cutting workpieces which are homogeneous, or composite materials having external layers with similar material properties on both sides, it is advantageous if both high-pressure fluid medium jets are directed at essentially identical angles against the main surfaces of the workpiece.

High cutting progress and at the same time clean cut lines can be achieved on both sides, especially in very thin covering layers of tough composite honeycomb materials, if the high-pressure fluid medium jets meet each other and are directed at an angle from 45° to 135°, especially from 60° to 120°, preferably over a 90° range, against the workpiece to be cut.

The just mentioned cutting results can even be improved if the total vector of the movement of the medium in both high-pressure fluid medium jets projecting in the main extension direction of the workpiece, and the relative movement of both jets on the one hand, and the workpiece on the other, are maintained in essentially the same direction. Thus, according to this particularly advantageous configuration, with an apparent or real movement of the workpiece in one direction in which the movement of the medium of both cutting jets takes place as well, the entire material moves into the angle of the meeting jets, which is smaller than 180°. A special advantage of this type of relative motion is that a significant part of the jet bundle resulting at the impact area of the two cutting jets is directed into the already existing parting line, and therefore does not create any disturbances in the workpiece.

Significant noise is developed with the new method operating with two meeting cutting jets which contain high kinetic energy, where high sound frequencies are amplified, in particular. However,

it was found that the noise is significantly reduced when the jets meet in an optimum manner. To test the quality or the adjustment of the cutting jet's position, or to finely adjust the cutting heads or the nozzles, it is particularly advantageous if the optimum meeting of the cooperating high-pressure fluid medium jets takes place while a minimum noise is being determined, preferably by means of ultrasonic sound meters.

Particularly good cutting results, in conjunction with a low occurrence of material destroyed by the cutting, and thin parting lines, especially in composite honeycomb materials, can be achieved if, as is preferred, the cooperating high-pressure fluid medium jets have essentially circular cross sections with a diameter of no more than 1.5 mm, particularly from 0.1 to 0.5 mm.

A relatively simple construction can be ensured, because the supply of the high-pressure fluid medium only requires one main supply line and provides cutting symmetry, if both high-pressure fluid medium jets operate at essentially the same pressure.

A further subject of the invention is a device for carrying out the new method, with a holding device for a flat material to be cut, and at least two nozzles on both sides thereof, with cutting center lines, with cutting heads that can be supplied with a fluid medium, where the holding device on the one hand, and the two nozzle heads on the other, move in relation to each other along a desired cutting course, which essentially consists in that the nozzles with the nozzle heads, possibly containing high-pressure hinge joints, comprise high-pressure lines with a fluid medium pressurized to at least 700 bar, preferably to at least 1000 bar, which are preferably coupled to each other and can be directed against the main sides of the workpiece at angles that differ from 90°, and are preferably hinged and can be fixed in the hinged position. A high degree of cutting quality and speed can be achieved with such a device, by

directing a flexible, precise adjustment of the impact angle of the cutting jets against the main surfaces of the material to be cut. A preferred clamped coupling can enable the simultaneous swinging of the nozzle heads while maintaining the meeting of the jets, so that always no more than one fine adjustment is required to achieve a high coverage of the cutting jets in the impact area.

Any disturbance of the jets during the cutting process is excluded if, as is preferred, the holding device is able to move along a desired cutting course, but grips the material outside of the desired cutting course area.

Another variation that favors the optimization of the cutting parameter is provided, if the nozzles can be adjusted and fixed at a constant angle with respect to each other, or to the main surfaces of the material to be cut, whereby a high flexibility with regard to adjusting the cutting process for material properties, material thickness and similar can be attained.

A particularly simple and precise adjustment of the impact point, especially with respect to its position within the material to be cut, is made possible if, as is preferred, the swivel axes of the nozzle are in a plane that is vertical with respect to the workpiece or its main surfaces.

Smooth linear cutting lines can be obtained if, as favorably provided, the swivel axes of the nozzles producing the high-pressure fluid medium jets are parallel to each other.

If an angled cut is desired, a type of construction is preferred in which the axes of the nozzle swing are at an angle with respect to each other, preferably an acute angle.

A quick optimization of the cutting process can be achieved if, as may be favorably provided further, at least one cutting head comprises a three-dimensionally adjustable and fixable device for finely adjusting the nozzle(s). This fine adjustment can also be microprocessor-controlled, e.g. using a sound meter as the sensor.

To ease the adjustment of the cutting jets, it may be favorable if they contain a device that provides low pressure to the fluid medium, e.g. up to 10 bar, for adjusting the impact area of the cooperating fluid medium jets.

Large amounts of spray mist occur when the high-energy medium jets impact each other. It was proven to be particularly favorable to individually equip the pairs of cutting heads with a hood that is adjustable to the distance of the impact area of the cooperating high-pressure medium jets from the connection line of the nozzles, and the hood contains a suction device for the spray mist. In moveable cutting heads, the hoods are attached to these or to their supporting structure, with the advantage that these hoods can be manufactured e.g. of a light plastic, since the spray mist only has low-energy densities.

The following cutting parameter ranges are favorable and achievable for cutting composite honeycomb materials in thicknesses of 1 - 5 cm:
High pressure: 1000 - 4000 bar, particularly 2500 - 3800 bar;
Jet diameter: 0.1 - 0.4 mm;
Cutting speed: 0.5 - 5 m/s, particularly 1 - 3 m/s;
Fluid medium consumption: 2 - 6 l/min.

The invention will be explained in greater detail by means of the following <u>example</u>.
A flat composite honeycomb material about 30 mm thick, a honeycomb width of about 5 mm, honeycomb material: glass fiber-reinforced

plastic or aluminum; coating: first main surface with aluminum, second main surface with fiber-reinforced plastic, both main surfaces with glass fiber-reinforced plastic or both main surfaces with aluminum, where the thickness of the honeycomb is 0.1 and the coating in the case of aluminum is 0.7 mm, with two nozzles directed at angles of 60°, 90° and 120° of their center lines, with high-pressure water jets meeting approximately in the center of the material to be cut. The jet diameters were 0.2 mm, the fluid medium pressure was 3500 bar. The nozzles were at a respective distance of 5 mm from the covering layer surfaces. The table shows at which cutting speeds, with reference to the above mentioned materials, clean cuts were obtained on both sides, while disturbances of the honeycomb structure at the cutting point were somewhat higher in aluminum, but always within an acceptable framework.

No.	Composite honeycomb			Cutting speed m/s jet angle γ	Cutting quality jet angle γ
	1. Coating	Honeycomb	2. Coating		

see table. Kunststoff = plastic.

*) 1 - smooth cut throughout

2 - smooth cut with insignificant irregularities

**) All composites with glass fiber-reinforced plastic

The invention will be explained in greater detail by means of the drawing, where figures 1 to 3 are side views of different nozzle positions, figures 4 to 6 are different schematic arrangements of the swivel axes of the jet nozzles, and figures 7 and 8 are side and top views of a new application. Figures 1 to 3 illustrate how a flat composite honeycomb material 7 with a thickness f with covering layers 71, 72 on both sides, is cut by a pair of nozzle heads 11, 12 on both sides of its main surfaces 711, 721, which can swivel around axes a1, a2 at a distance of b and c from the workpiece

surfaces 711 and 721 and d from each other, containing nozzles 21, 22, by means of equally thick high-pressure fluid medium jets 31, 32 and produce the cutting line S, where in this case the nozzles 21, 22 are stationary and the material 7 moves in the direction r. In accordance with figure 1, the two jets 31, 32 are directed against the main surfaces at angles α, ß of 90° each, and at an angle γ of exactly 180° with respect to each other, where the great disadvantage is that the resulting jet bundle 35 in the impact area 64 extends transversely to all sides and destroys much of the honeycomb structure of workpiece 7.

According to figures 2 and 3, the jets 31, 32 are directed against each other at equal angles α, ß of 60° and 45° respectively, while they include an angle γ of 120° and 90° at the impact area 64, in the honeycomb area 73 of workpiece 7. In figure 2, suction hoods 81, 82 with suction stubs 811, 821 for drawing off the spray mist that forms at the impact point 64, are located and can be adjusted to the distance z from the connection line d of the nozzle heads 11, 12. With the nozzle position in figure 2, which also agrees with the invention like the one in figure 3, a higher jet energy destructive density is achieved, however the disturbances caused by the structure of the jet bundle 35 at the cut S are potentially larger then with the cutting illustrated in figure 3.

Figure 2 indicates the vectors s1, s2 of the fluid movement of jets 31, 32, and their total vector V extending in the same direction as the movement r of material 7, in addition to a plane e that is vertical to the workpiece, in which both swivel axes a1 and a2 of the nozzles 21, 22 are located, as well as the distance z between the connection d of the two nozzles and the impact point 64 where the jets 31, 32 meet each other.

Figures 4 to 6 schematically depict how a plane e, which is essentially vertical to the material 7 being cut, can comprise the

swivel axes a1, a2 in which the nozzle heads 11, 12 that discharge the cutting jets 31, 32 are arranged, where a vertical cut S takes place when the axes a1, a2 are parallel according to figure 4, and the connection between the nozzle heads 11, 12 is also vertical with respect to the workpiece; and an angled cut can be achieved with the nozzle heads 11, 12 with an inclined connection d of the parallel swivel axes a1, a2 according to figure 5; and a V-shaped cut S is achieved when the swivel axes a1, a2 are placed at an angle δ with respect to each other according to figure 6. These principal types of cuts can easily be interchanged, in reference to the later application with a corresponding nozzle tandem. It should finally be pointed out that the impact angles α, β of both nozzle jets with respect to the workpiece 7 can also be different from each other, which can be an advantage e.g. with differently coated composite materials.

In the concrete configuration examples of a cutting device of the invention for plates made of composite honeycomb materials, as illustrated in figures 7 and 8, a processing frame 8 supports a holding fixture 80 for the cutting device, which is horizontally guided along 81, and contains a guide 82 that can move vertically and comprises a vacuum head 83 with a suction line 84, which holds a composite honeycomb plate 7 for vertical trimming, which is able to move in that position, and contains two angled nozzle heads 11, 12 that discharge high-pressure cutting jets 31, 32 inside a sound chamber 95 with suction stubs 96 for the spray mist of a cutting device 100, which in this case is held horizontally but could also move vertically, and is guided across the gap 951 in chamber 95, while the material 7 to be cut is held above the dual-nozzle cutting unit 11, 12 on both sides, by means of a transportation device with pneumatic installations 94, 94′ for adapting to the thickness f of the material to be cut, which is equipped with conveyor units 93, 93′ that guide it past the dual nozzle unit 11, 12, at a speed and in a position that can be adjusted from the control desk 90, and is

cut by the vertical jets 31, 32 which move in tandem. The dual nozzle unit 11, 12 is supplied from the high-pressure aggregate 97, which is only indicated schematically, via a high-pressure line 98, where the control and adjustment of the device is preferably automatic, with all processes from picking up the uncut plate 7 to its release being initiated from the above mentioned control desk 90 by means of actuators 92 for the valves that regulate the high-pressure medium flow, and the pressure control device 91.

Patent claims

1. A method for separating or cutting a flat material (7) by means of nozzles (21, 22) arranged on both sides thereof, which discharge jets (31, 32) that intersect inside the material, with the pressurized flow of a fluid medium, preferably water, where the jets on the one hand and the flat material on the other move in relation to each other along a desired cutting course, characterized in that, to separate or cut workpieces (7) with flat extensions, particularly two main surfaces with self-supporting rigid materials, particularly composite materials, preferably with covering layers (71, 72) supported by an inner honeycomb structure (73), where the workpiece (7) on the one hand, and at least one set of nozzles (21, 22) on the other are located on both sides of the workpiece, producing a high pressure of at least 700 bar, preferably at least 1000 bar on the inside, preferably in the central area of the workpiece, and preferably meet at an angle (γ) with respect to each other which can be fixed or changed, cooperating fluid medium jets (31, 32) move with respect to each other in the impact area (64), and preferably comprise at least a nearly coinciding cross section surface and/or shape, where each of the meeting high-pressure fluid medium jets (31, 32) are directed against the main surfaces (711, 721) of the workpiece (7) along the entire cutting course, at an angle that differs from 90° (α, β).

2. A method as claimed in claim 1, characterized in that the coverage of the cross section surfaces of both high-pressure fluid medium jets (31, 32) is adjusted in their impact area (64) to at least 90%, particularly to at least 95%.

3. A method as claimed in claim 1 or 2, characterized in that the two high-pressure fluid medium jets (31, 32) are directed against the main surfaces (711, 721) of the workpiece (7) at essentially identical angles (α and β) with respect to each other.

4. A method as claimed in one of claims 1 to 3, characterized in that the high-pressure fluid medium jets (31, 32) are directed against the workpiece (7) at an angle (γ) of 45° to 135°, especially from 60° to 120°, and preferably meet in the area of about 90°.

5. A method as claimed in one of claims 1 to 4, characterized in that the total vector (v) of the movement of the medium in both high-pressure fluid medium jets (31, 32), and the relative movement of both jets (31, 32) on the one side of the workpiece (7) and on the other, are projected in the main direction of the workpiece extension, and are kept in essentially the same direction (r).

6. A method as claimed in one of claims 1 to 5, characterized in that an adjustment of the optimum meeting of the two cooperating high-pressure fluid medium jets (31, 32) is made by determining the minimum sound, preferably by means of ultrasonic sound meters.

7. A method as claimed in one of claims 1 to 6, characterized in that the cooperating high-pressure fluid medium jets (31, 32) have essentially circular cross section surfaces with a diameter of no more than 1.5 mm, especially from 0.1 to 0.5 mm.

8. A device for carrying out the method claimed in one of claims 1 to 8, with a holding device for a flat material (7) to be cut, and

at least two nozzles (21, 22) directed against the material on both sides thereof, with meeting center lines, with cutting heads (11, 12) containing a pressurized fluid, where the holding device one the one hand and the two nozzle heads (11, 12) on the other move in relation to each other along a desired cutting course, characterized in that the nozzles (21, 22) of the nozzle heads (11, 12), with possible high-pressure swivel links, containing a fluid medium (3) pressurized to at least 700 bar, preferably to at least 1000 bar, are coupled to each other at angles (α, ß) which differ from 90°, and are directed against the main sides (71, 72), particularly the main surfaces (711, 721) of the workpiece (7), while they are able to swivel and can be fixed in their swivel position.

10. A device as claimed in claim 9, characterized in that the holding device for the workpiece (7), which can move along a desired cutting course, is formed to grip from outside of the desired cutting course area.

11. A device as claimed in claim 9 or 10, characterized in that the nozzles (21, 22) are at a constant angle with respect to each other, and that their distance (d) from each other, or (b, c) from the main surfaces (711, 721) of the workpiece (7) to be cut, can be changed and fixed.

12. A device as claimed in one of claims 9 to 11, characterized in that the swivel axes (a1, a2) of nozzles (21, 22) are arranged within a plane (e) that is vertical with respect to the workpiece (7), or its main surfaces (711, 721).

13. A device as claimed in one of claims 9 to 12, characterized in that the swivel axes (a1, a2) of the nozzles (21, 22) that discharge the high-pressure fluid medium jets (31, 32), are arranged parallel to each other.

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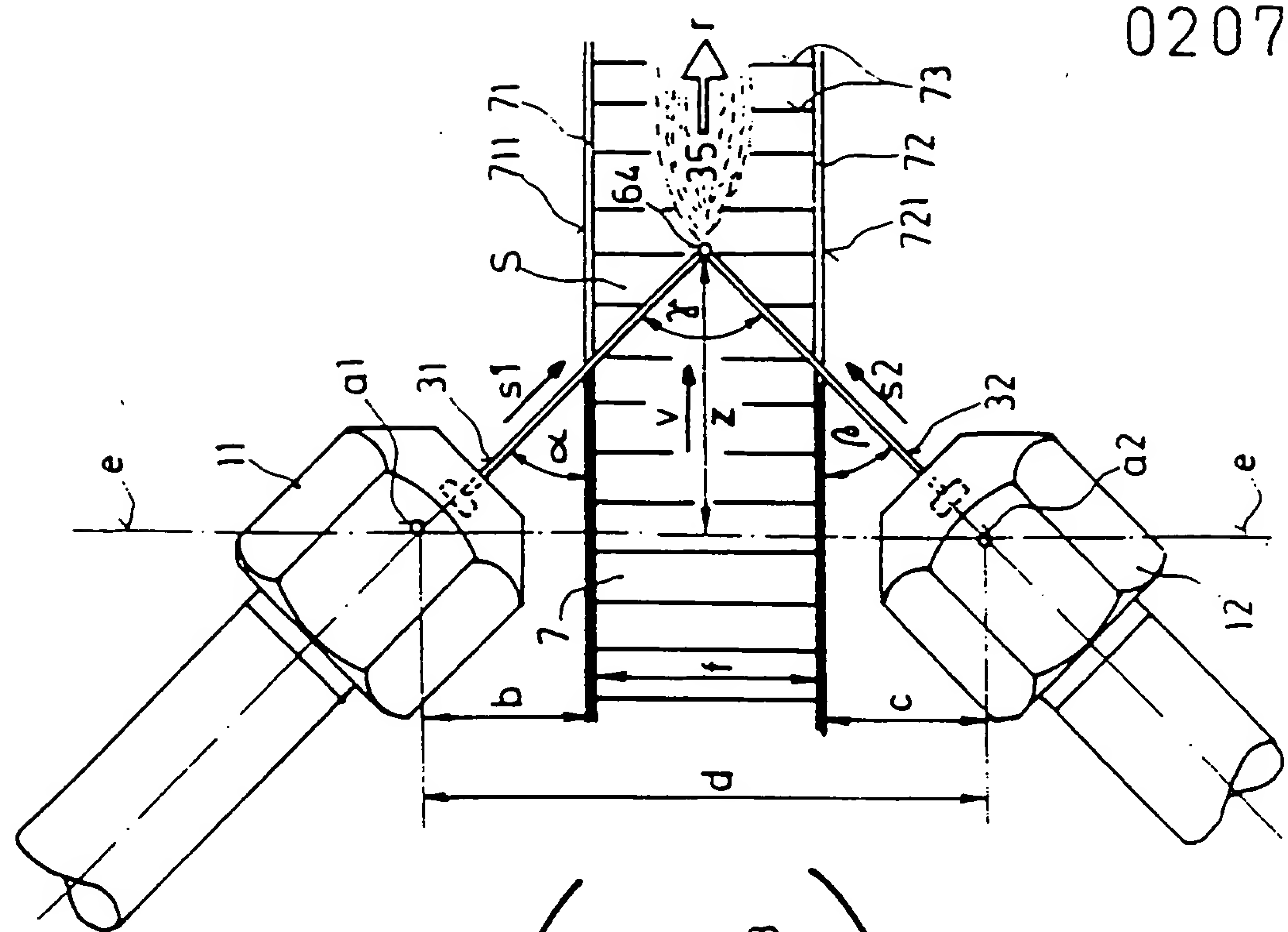

Fig. 3

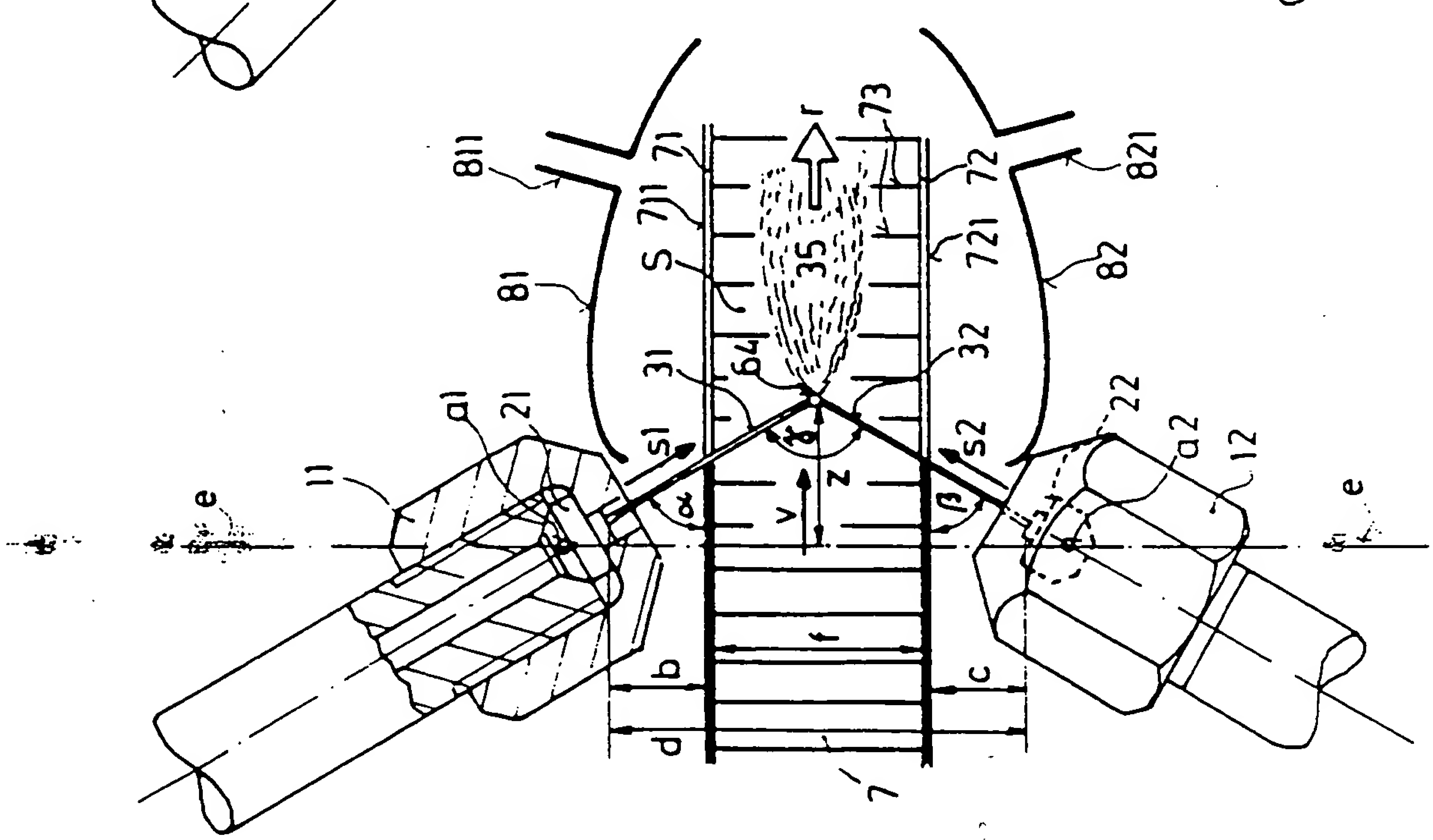

Fig. 2

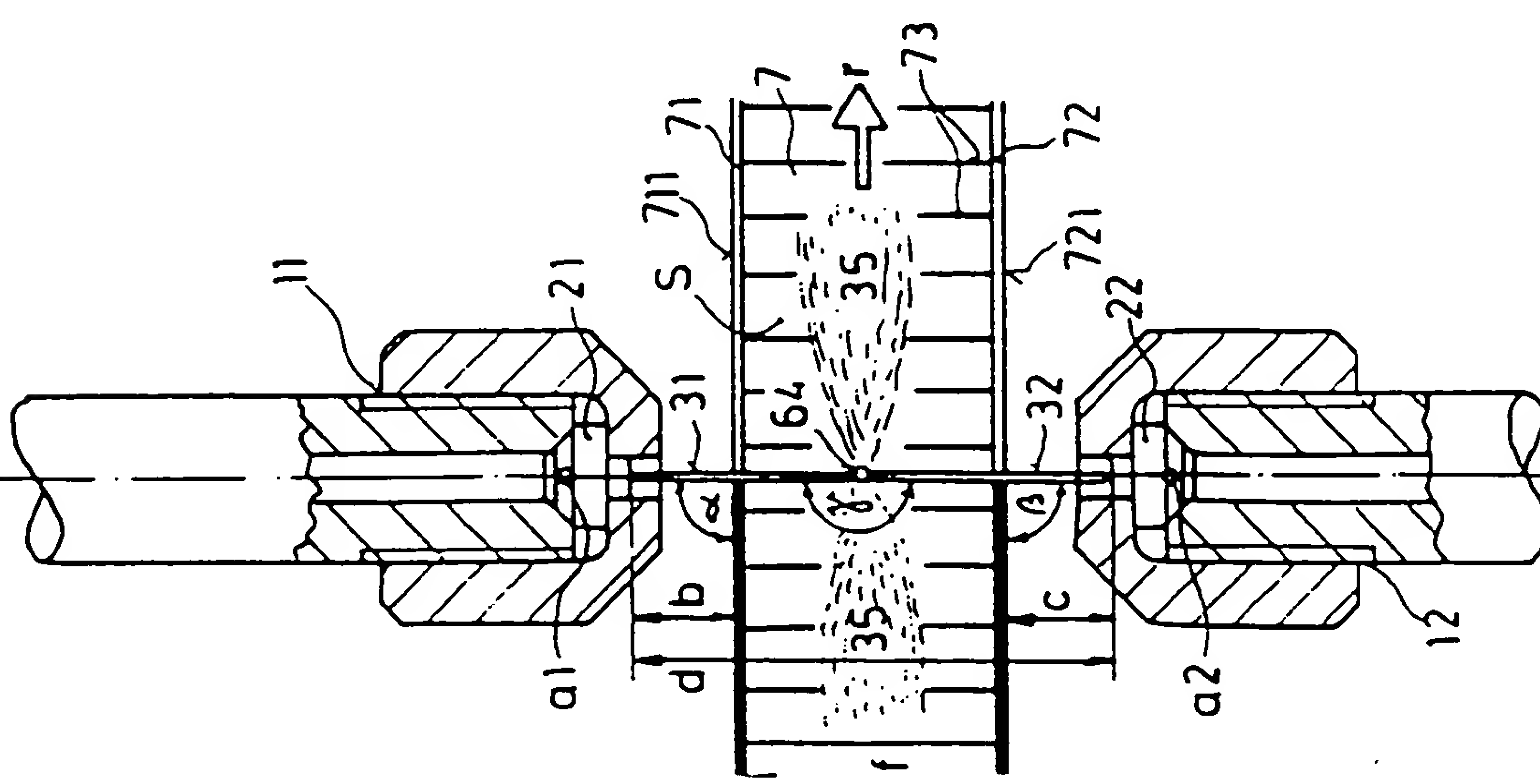

Fig. 1

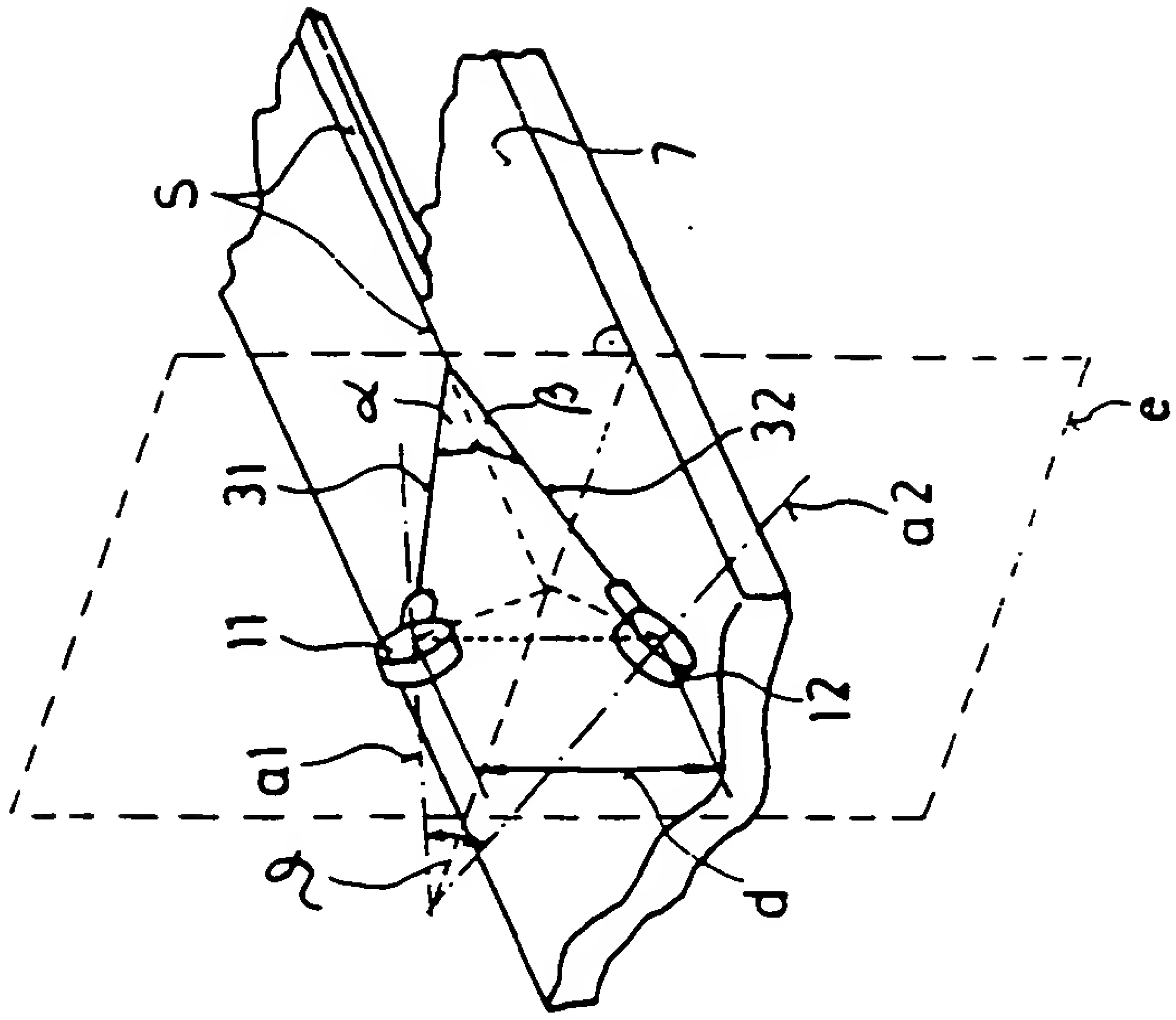

Fig. 6

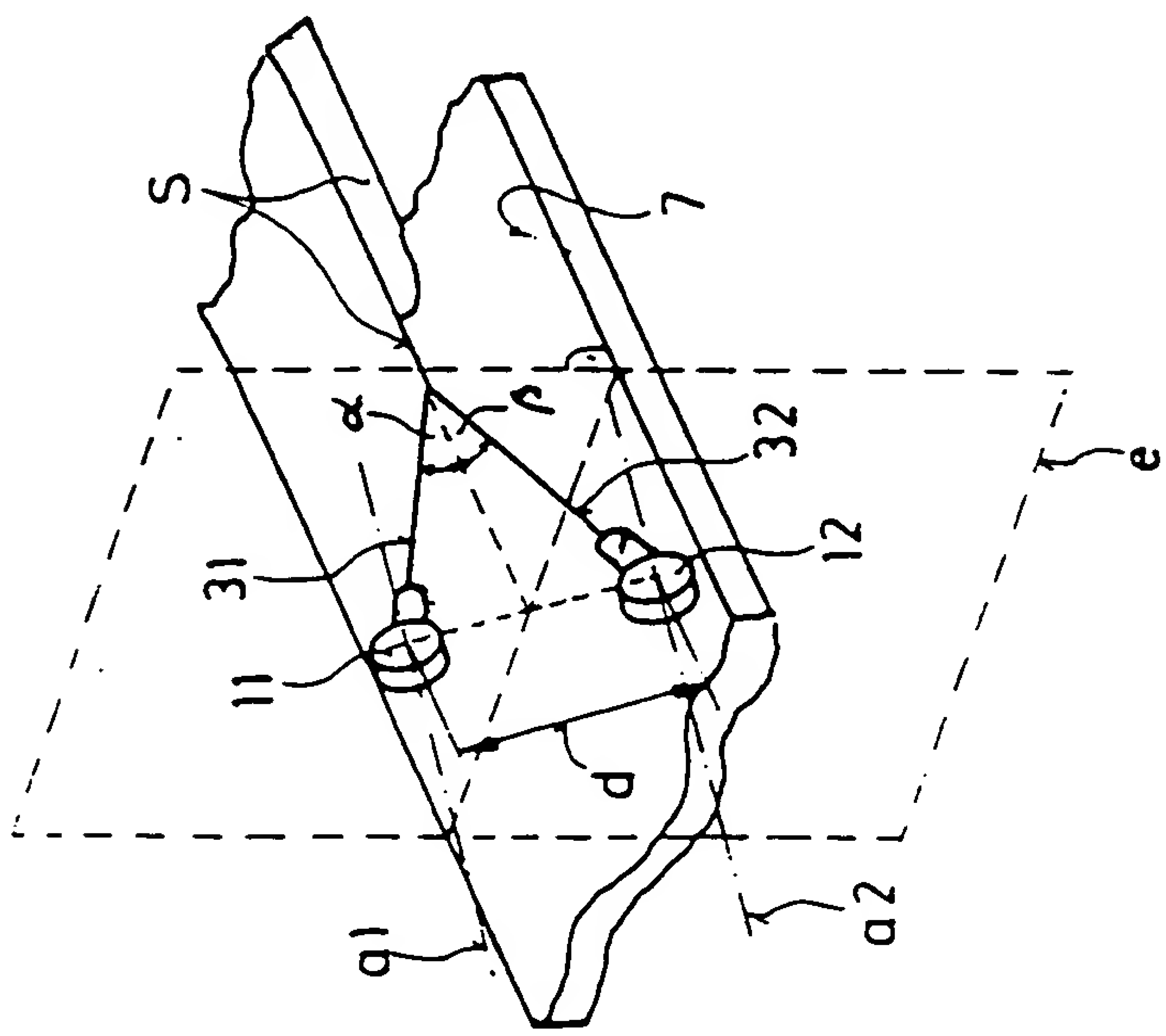

Fig. 5

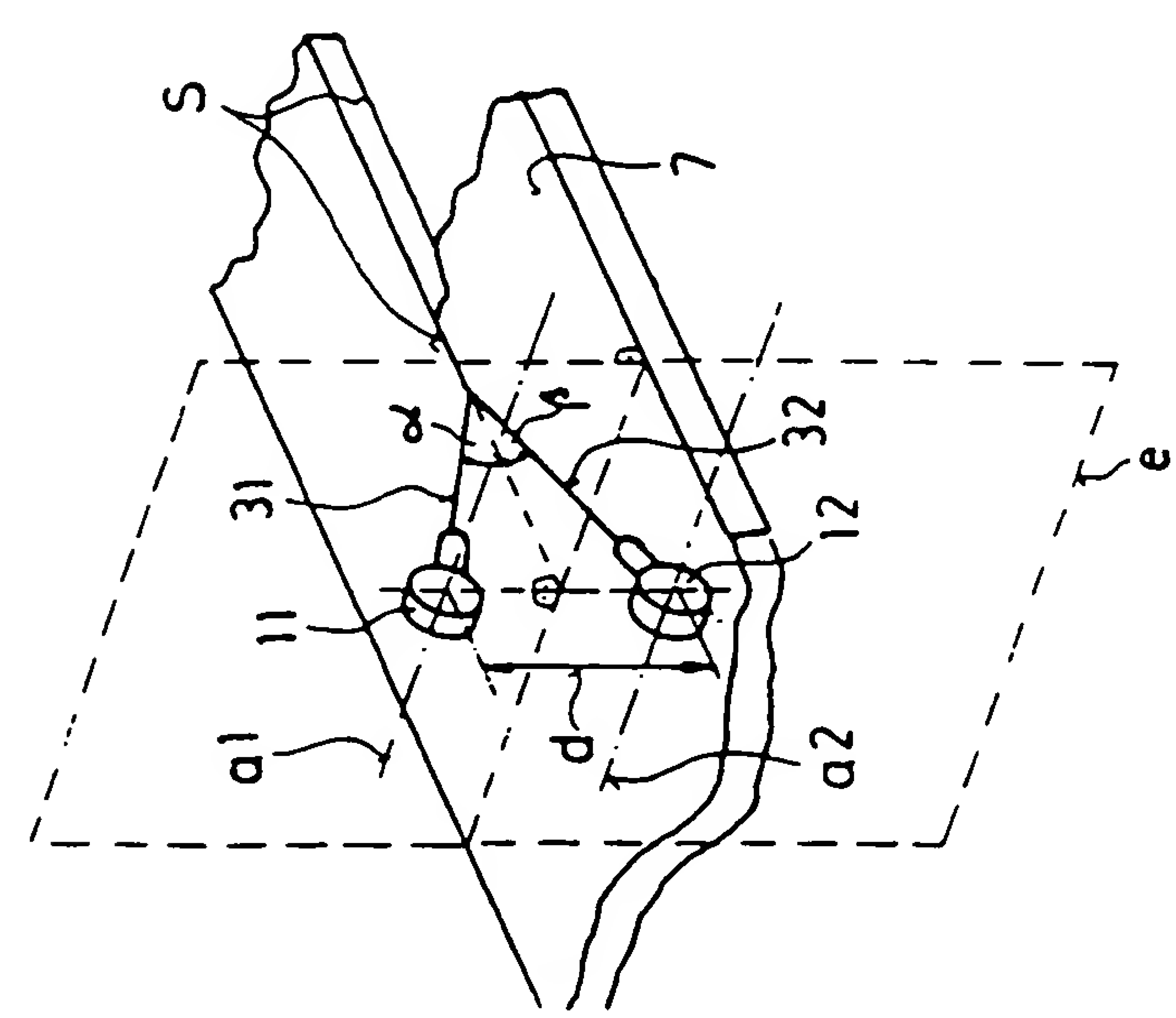

Fig. 4

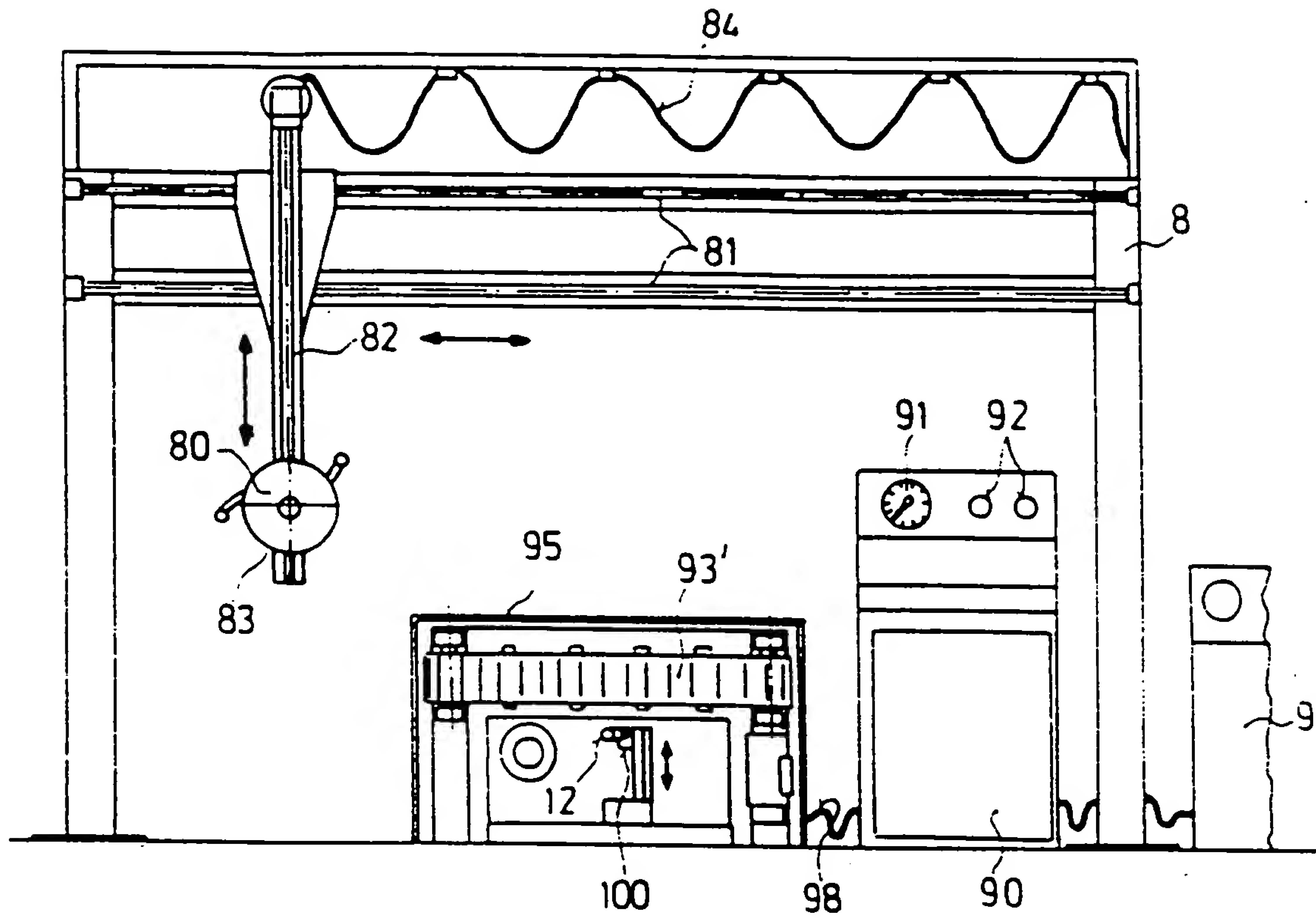
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Fig. 7

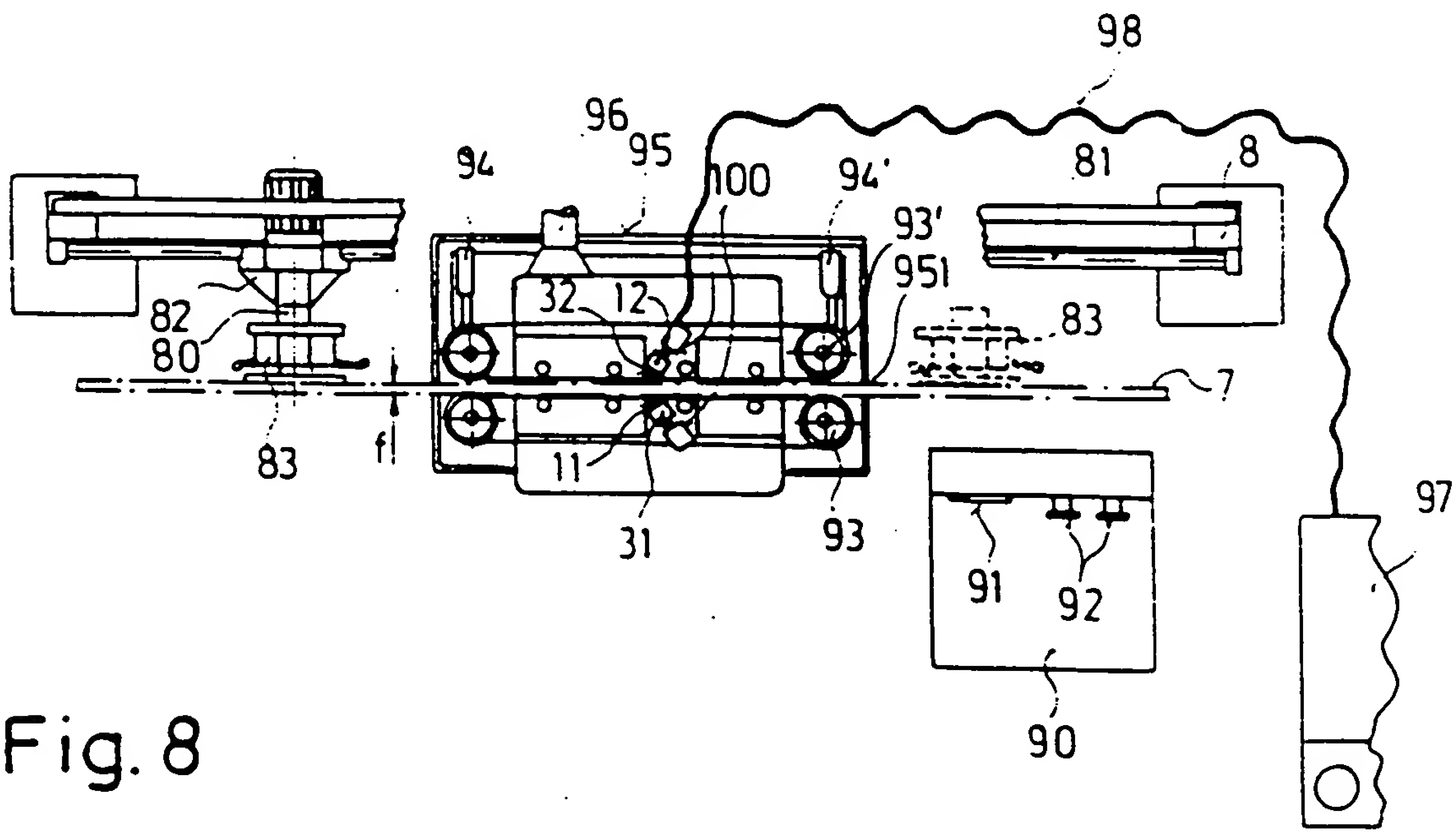
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Fig. 8